WORK CHUCKING/INSERTING APPARATUS AND ASSEMBLING UNIT

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a work chucking/inserting apparatus and more particularly to a work chucking/inserting apparatus capable of handling various sizes of works in inserting a work into an insertion hole in an aligned state with the insertion hole and capable of attaining the insertion with a simple structure in a short time and in a high working efficiency.

Description of the Prior Art

In inserting a work into an insertion hole and fitting them together with use of such a machine as a robot, conventional techniques correct a positional deviation between the insertion hole and the present position of the work by using a jig for insertion or using a Vision (a two-dimensional visual device) to detect the position of the insertion hole.

For example, in the case where a jig for insertion is used (Japanese Patent Laid Open No. 115129/84), as shown in Fig. 17, an inserting jig 01 has an inlet larger than an insertion hole 02. The portion adjacent to the inlet is tapered or gently curved and leads to an outlet (insertion port) which is of the same shape as an inlet portion of the insertion hole 02 located on the side opposite to the inlet of the inserting jig 01.

The inserting jig 01 having such a shape is first placed on the opening of the insertion hole 02 formed in an object (e.g., cylinder) 05 so as to be in approximate alignment with the insertion hole 02. At this time, the axis of the inserting jig 01 and that of the insertion hole 02 are not in exact alignment with each other. In this state, an expander 03 having

plural fingers capable of expanding from the inside toward the outside is inserted into the insertion hole 02 and then the plural fingers are expanded outwards. As a result, the inserting jig 01 moves and the axis thereof comes into alignment with the axis of the insertion hole 02 (see Fig. 18). In this state the inserting jig 01 is fixed so as not to move.

Next, a work (e.g., piston) 04 is pushed in toward the insertion hole 02 while allowing to follow the tapered shape of the inserting jig 01, whereby the work 04 passes through the outlet of the inserting jig 01 and is inserted into the insertion hole 02 (see Fig. 19).

However, in such a conventional method which uses the inserting jig 01, it is necessary that the shape of the jig 01 be in conformity with the shape of the insertion hole; that is, it is necessary to provide inserting jigs 01 in a number corresponding to the number of types of insertion holes. Besides, the expander 03 is also needed and an extra working time is required for the aligning work using the expander. Under the circumstances, in a multi-type mixed production line handling more than three types, the application of the method using the inserting jig 01 is difficult. For example, in an engine assembling line as a multi-type mixed production line, the process of inserting a piston into a cylinder bore is in many cases carried out by manual operation.

As another method using a jig there is known a method (Japanese Patent Laid Open No. 256526/92) wherein a position detecting jig is moved and is allowed to follow an insertion hole while searching for the position of the insertion hole with use of a force control. In this method, however, a work chucking/inserting apparatus is required to shift the jig and a component from one to the other. This is time-consuming and a shift error occurs after repetition of such jig shifting operation. As methods which

utilize similar tracing mechanisms there are known methods (Japanese Patent Laid Open Nos. 108108/93 and 168927/96) wherein the position of an insertion hole is detected while allowing a work itself to contact and follow the insertion hole. But both methods involve problems such as the damage of components because the work itself is brought into contact with the insertion hole for detecting the position of the same hole.

Next, in case of using a Vision (a two-dimensional visual device), a positional deviation between a work and an insertion hole is detected by the Vision, position data of a robot for chucking and conveying the work are corrected, and the work is inserted into the insertion hole at an exact robot position. However, since the Vision is relatively expensive, an increase of cost results.

Moreover, the accuracy of the measurement made by the Vision does not become higher than the resolution thereof, so for a highly accurate detection of the hole position it is necessary to take a close-up of the hole, requiring three or more cameras in the case of a large hole. An attempt to enhance the accuracy results in a further increase of cost. Besides, a correcting work for matching both Vision and robot coordinate systems is troublesome and a complete matching is impossible, that is, the occurrence of an error is unavoidable. Mechanical changes (e.g., changes in weight and temperature, and shock), a change in illumination, and a change in optical conditions of the hole also give rise to an error.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a work chucking/inserting apparatus capable of solving the above-mentioned problems involved in the conventional means which is for inserting a work

into an insertion hole in alignment with the hole, also capable of handling various sizes of works and capable of inserting a work into an insertion hole in an aligned state with the hole in a short time and in a high working efficiency with use of a simple structure.

For achieving the above-mentioned object, in the first aspect of the present invention there is provided a work chucking/inserting apparatus to be used for chucking a work and inserting the work into an insertion hole in alignment with the hole, the work chucking/inserting apparatus including three or more chuck fingers, the chuck fingers being arranged in circumferentially spaced positions and capable of advancing and retreating radially, inner surfaces of the chuck fingers serving as chuck surfaces for chucking the work, and outer surfaces of the chuck fingers being tapered at least at tip end portions thereof so that the closer to the tips, the more inwards the taper, and capable of coming into contact with an inlet of the insertion hole.

Since the work chucking/inserting apparatus in the first aspect of the invention is constructed as above, the outer surfaces of the three or more chuck fingers arranged in spaced circumferential positions assume a generally conical shape, which is suitable for searching for the position of a work insertion hole. When the outer surfaces of the plural chuck fingers having such a shape are brought into contact equally with the inlet of the insertion hole, it becomes possible to detect the position of the insertion hole accurately, and by a simple operation involving fixing the work chucking/inserting apparatus to the detected position and pushing in the work as chucked by the inner surfaces of the chuck fingers toward the insertion hole, it is made possible to insert the work into the insertion hole in an aligned state with the hole. This can be done with an extremely

simple structure and that in a short time and a high working efficiency. In this case, the work chucking/inserting apparatus, after detecting the position of the insertion hole, memorizes the detected position and goes to a work feed place to fetch the work.

Besides, the chuck fingers of the chucking/inserting apparatus can advance and retreat radially, so by adjusting the advance and retreat of the chuck fingers radially in accordance with the size of the work it is possible to chuck, or handle, various sizes of works. Thus, this work chucking/inserting apparatus is suitable for use in an article assembling line as a multi-type mixed production line.

In the second aspect of the present invention there is provided a work chucking/inserting apparatus to be used for chucking a work and inserting the work into an insertion hole in alignment with the hole, the work chucking/inserting apparatus including three or more chuck fingers, the chuck fingers being arranged in circumferentially spaced positions and capable of advancing and retreating radially, inner surfaces of the chuck fingers serving as chuck surfaces for chucking the work, and outer surfaces of the chuck fingers having at least at tip end portions thereof surfaces parallel to an inner peripheral surface of the insertion hole, and capable of being brought into contact with an inlet of the insertion hole.

Since the work chucking/inserting apparatus in the second aspect of the invention is constructed as above, the outer surfaces of the three chuck fingers arranged in spaced circumferential positions assume a generally cylindrical shape, which is suitable for searching for the position of a work insertion hole. When the outer surfaces of the plural chuck fingers having such a shape are brought into contact equally with the inlet of the insertion hole, it becomes possible to detect the position of the

insertion hole accurately, and by a simple operation involving fixing the work chucking/inserting apparatus to the detected position and pushing in the work as chucked by the inner surfaces of the chuck fingers toward the insertion hole, it is made possible to insert the work into the insertion hole in an aligned state with the hole. This can be done with an extremely simple structure and that in a short time and a high working efficiency. Also in this case, the work chucking/inserting apparatus, after detecting the position of the insertion hole, memorizes the detected position and goes to the work feed position to fetch the work.

Besides, the chuck fingers of this work chucking/inserting apparatus can advance and retreat radially, so by adjusting the advance and retreat of the chuck fingers radially in accordance with the work size it is possible to chuck, or handle, various sizes of works. Thus, this work chucking/inserting apparatus is suitable for use in an article assembling line as a multi-type mixed production line.

In the third aspect of the present invention there is provided a work chucking/inserting apparatus to be used for chucking a work and inserting the work into an insertion hole in alignment with the hole, the work chucking/inserting apparatus including three or more chuck fingers and three or more hole position detecting fingers, the chuck fingers being arranged in circumferentially spaced positions and capable of advancing and retreating radially, the hole position detecting fingers being arranged in circumferentially spaced positions and pivotable inwards and outwards, centered on base end portions thereof, inner surfaces of the chuck fingers serving as chuck surfaces for chucking the work, and outer surfaces of the hole position detecting fingers being tapered at least at tip end portions thereof so that the closer to the tips, the more inwards the taper, and

capable of coming into contact with an inlet of the insertion hole.

Since the work chucking/inserting apparatus in the third aspect of the present invention is constructed as above, the outer surfaces of the three or more hole position detecting fingers, which are arranged in circumferentially spaced positions so as to be pivotable inwards and outwards with their base end portions as fulcrums, are generally conical at least at their tip end portions, which conical shape is suitable for searching for the position of the work insertion hole. When the outer surfaces of the plural hole position detecting fingers having such a shape are brought into contact equally with the inlet of the insertion hole, it becomes possible to detect the position of the insertion hole accurately, and by a simple operation involving fixing a body portion of the work chucking/inserting apparatus to the detected position and pushing in the work as chucked by the inner surfaces of the chuck fingers toward the insertion hole, it is made possible to insert the work into the insertion hole in an aligned state with the hole. Besides, in this case, the work chucking/inserting apparatus, after detecting the position of the insertion hole, need not go to the work feed place and fetch the work. Thus, with an extremely simple structure, the work can be inserted into the insertion hole in an aligned state with the hole in a short time and in a high working efficiency.

Besides, the chuck fingers used in this work chucking/inserting apparatus can advance and retreat radially, so by adjusting the advance and retreat of the chuck fingers radially in accordance with the work size it is possible to chuck, or handle, various sizes of works. Thus, this work chucking/inserting apparatus is suitable for use in an article assembling line as a multi-type mixed production line.

In the fourth aspect of the present invention there is provided, in

combination with the above third aspect, a work chucking/inserting apparatus wherein the base end portions of the hole position detecting fingers are pivotally connected to tip end portions of the chuck fingers. According to this construction, when the work as chucked by the inner surfaces of the chuck fingers is inserted into the insertion hole, it is only a mechanical error between the hole position detecting fingers and the chuck fingers that comes into question. Since this error is very small and can be corrected relatively easily, the work can be inserted into the insertion hole accurately in alignment with the hole.

In the fifth aspect of the present invention there is provided, in combination with the above third aspect, a work chucking/inserting apparatus wherein the base end portions of the hole position detecting fingers are pivotally connected to a base portion by which base end portions of the chuck fingers are supported for radial advance and retreat. According to this construction, when the work as chucked by the inner surfaces of the chuck fingers is inserted into the insertion hole in alignment with the hole, a mechanical error between the hole position detecting fingers and the chuck fingers through the base portion comes into question. But since this error is relatively small and can be corrected, the work can be inserted into the insertion hole accurately in alignment with the insertion hole. Besides, the hole position detecting fingers can be pivotally supported in a more firm and stable manner.

In the sixth aspect of the present invention there is provided, in combination with any of the above first to fifth aspects, a work chucking/inserting apparatus further including a tracer mechanism which, when the outer surfaces of the chuck fingers or of the hole position detecting fingers come into contact with the inlet of the insertion hole, causes the axis

of a conical surface defined by the outer surfaces of the three or more chuck fingers or of the three or more hole position detecting fingers to be aligned with the axis of the insertion hole. Thus, by a mere operation of causing the outer surfaces of the chuck fingers or the hole position detecting fingers to advance toward the insertion hole, it is possible to detect the position of the insertion hole, that is, the position of the insertion hole can be detected extremely easily.

In the seventh aspect of the present invention there is provided, in combination with any of the above first to sixth aspects, a work chucking/inserting apparatus further including a pushing mechanism for pushing the work toward the insertion hole. According to this construction, when the position of the insertion hole has been detected, the chuck fingers have chucked the work and the axis of a cylindrical surface formed by the inner surfaces of the chuck fingers has become aligned with the axis of the insertion hole, it immediately becomes possible to push the work into the insertion hole. Thus, in a still shorter time and in a still higher working efficiency the work can be inserted into the insertion hole in alignment with the axis of the hole.

In the eighth aspect of the present invention there is provided, in combination with any of claims first to seventh, a work chucking/inserting apparatus wherein the inlet of the insertion hole is chamfered and tip end portions of the chuck fingers are respectively formed with projections which can fill up the chamfered portion when the work is inserted into the insertion hole. As a result, even if the inlet of the insertion hole is chamfered, an inner peripheral surface of the insertion hole and a cylindrical surface formed by the inner surfaces of the chuck fingers become contiguous to each other. Besides, the chuck fingers are received by the

chamfered portion and come to a standstill, so even if the work (e.g. piston) has a protuberance (e.g. piston ring) on its outer surface, the work can be inserted smoothly into the insertion hole (e.g., cylinder bore). Thus, such a protuberance is not an obstacle to an aligned insertion of the work into the insertion hole.

In the ninth aspect of the present invention there is provided, in combination with any of the above first to eighth aspects, a work chucking/inserting apparatus wherein the work is a piston or an assembly of a piston and a connecting rod, and the insertion hole is a cylinder bore. According to this construction, the work for inserting the piston or the piston-connecting rod assembly into the insertion hole in alignment with the hole can be done with an extremely simple structure and that in a short time and in a high efficiency.

In the tenth aspect of the present invention there is provided, in combination with the above third aspect, a work chucking/inserting apparatus wherein the work is an assembly of a piston and a connecting rod, the insertion hole is a cylinder bore, the chuck fingers chuck the piston, and the hole position detecting fingers also serve as means for chucking the connecting rod. According to this construction, the means for chucking the connecting rod can be constituted in an extremely simple manner without using any separate member.

In the eleventh aspect of the present invention there is provided a work chucking/inserting apparatus to be used for chucking a work and inserting the work into an insertion hole in alignment with the hole, the work chucking/inserting apparatus including three or more chuck fingers, the chuck fingers being arranged in circumferentially spaced positions and capable of advancing and retreating radially, inner surfaces of the chuck

fingers serving as chuck surfaces for chucking the work and each having a portion tapered such that the closer to the tip thereof, the more inwards the taper, outer surfaces of the chuck fingers being tapered at least at tip end portions thereof so that the closer to the tips, the more inwards the taper, and capable of coming into contact with an inlet of the insertion hole, the work chucking/inserting apparatus also including a tracer mechanism for causing the axis of a conical surface defined by the outer surfaces of the three or more chuck fingers to be aligned with the axis of the insertion hole when the said outer surfaces come into contact with the inlet of the insertion hole, and further including a pushing mechanism for pushing the work toward the insertion hole.

Since the work chucking/inserting apparatus in the eleventh aspect of the invention is constructed as above, not only it can exhibit the same effects as those mentioned in the above first, sixth and seventh aspects of the invention, but also it can attain the following effects.

The inner surfaces of the chuck fingers are formed as chuck surfaces for chucking the work, each having a portion tapered such that the closer to the tip thereof, the more inwards the taper, and the work chucking/inserting apparatus is further provided with a push mechanism for pushing the work toward the insertion hole. Therefore, even if the inner surfaces of the chuck fingers have already chucked the work when the work chucking/inserting apparatus is detecting the position of the insertion hole, the work chucking/inserting apparatus, after detection of the insertion hole position, stands still in the detected position and only the chuck fingers expand their tips radially outwards, permitting the work to pass therethrough. At this time, the pushing mechanism pushes the work, allowing the work to slide on the tapered portions of the inner surfaces of

the chuck fingers. As a result, without disengagement or drop of the work from the chuck fingers, the work can be inserted smoothly into the insertion hole while being guided by the tapered portions. Thus, after detection of the insertion hole position, the work chucking/inserting apparatus is not required to memorize the detected position and go to the work feed place to fetch the work. In other words, it becomes possible to insert the work into the insertion hole in alignment with the hole in a still shorter time and in a still higher working efficiency. Further, for eliminating the need of going to the work feed place and fetching the work it is no longer required to provide special hole position detecting fingers separately from the work chuck fingers, that is, the structure of the work chucking/inserting apparatus is not complicated.

In the twelfth aspect of the present invention there is provided, in combination with the above eleventh aspect, a work chucking/inserting apparatus wherein the inlet of the insertion hole is chamfered, and the tips of the outer surfaces of the chuck fingers are formed so that they can come into abutment against the chamfered portion when the work is inserted into the insertion hole. According to this construction there can be attained the same effect as in the above eighth aspect.

In the thirteenth aspect of the present invention there is provided a work chucking/inserting apparatus to be used for chucking a work and inserting the work into an insertion hole in alignment with the hole, the work chucking/inserting apparatus including three or more chuck fingers, the chuck fingers being arranged in circumferentially spaced positions and capable of advancing and retreating radially, inner surfaces of the chuck fingers serving as chuck surfaces for chucking the work and each having a portion tapered such that the closer to the tip thereof, the more inwards the

taper, end faces of the chuck fingers being flat at their portions except their portions close to their inner peripheral edges, and capable of coming into abutment against a wall surface which surrounds an inlet of the insertion hole, the said portions close to the inner peripheral edges being tapered such that the closer to the tips, the more inwards the taper, and capable of coming into contact with the inlet of the insertion hole, the inlet of the insertion hole being chamfered, the portions close to the inner peripheral edges of the end faces of the chuck fingers being capable of coming into abutment against the chamfered portion of the inlet of the insertion hole when the work is inserted into the insertion hole, the work chucking/inserting apparatus also including a tracer mechanism for causing the axis of a conical surface defined by the portions close to the inner peripheral edges of the end faces of the three or more chuck fingers to become aligned with the axis of the insertion hole when the portions close to the said inner peripheral edges come into contact with the inlet of the insertion hole, and the work chucking/inserting apparatus further including a pushing mechanism for pushing the work toward the insertion hole.

Since the work chucking/inserting apparatus in the thirteenth aspect of the invention is constructed as above, not only there can be attained the same effects as in the above eleventh and twelfth aspect but also the following effects can be obtained.

Since the end faces of the chuck fingers are flat at their portions except their portions close to their inner peripheral edges and can be brought into abutment against a wall surface which surrounds the inlet of the insertion hole and since the said portions close to the inner peripheral edges are tapered such that the closer to their tips, the more inwards the taper, and can come into contact with the inlet of the insertion hole, the flat

portions of the end faces of the chuck fingers can be allowed to serve as positioning faces for positioning the work chucking/inserting apparatus in the axial direction of the insertion hole when the same apparatus detects the position of the insertion hole by utilizing the tapered portions close to the inner peripheral edges of the end faces of the chuck fingers. As a result, the work chucking/inserting apparatus can be kept standstill in the axial direction of the insertion hole; besides, it is also possible to eliminate deflection of the axis and hence possible to improve the accuracy in detecting the position of the insertion hole.

In the fourteenth aspect of the present invention there is provided, in combination with any of the above eleventh to thirteenth aspects, a work chucking/inserting apparatus wherein the work is a piston or an assembly of a piston and a connecting rod, and the insertion hole is a cylinder bore. According to this construction, there can be attained the same effect as in the above ninth aspect.

In the fifteenth aspect of the present invention there is provided, in combination with any of the above eleventh to fourteenth aspects, a work chucking/inserting apparatus wherein the pushing mechanism possesses a work sucking function for sucking the work. According to this construction, even if the inner surfaces of the chuck fingers have already chucked the work before the work chucking/inserting apparatus detects the position of the insertion hole, and when the tip ends of the outer surfaces of the chuck fingers are expanded radially outwards due to passing of the work therethrough or for detecting the position of the insertion hole, since the pushing mechanism sucks the work, there is no fear of disengagement or drop of the work from the work chucking/inserting apparatus, nor is there any fear of deflection of the apparatus posture, thus permitting the work to

be inserted into the insertion hole positively and smoothly. Besides, since the work is little pushed by the pushing mechanism for slide on the tapered portions of the inner surfaces of the chuck fingers, there is no fear of damage to the work.

In the sixteenth aspect of the present invention there is provided an assembling unit comprising a robot which conveys the work chucking/inserting apparatus described in any of the above first to fifteenth aspects up to the position of the insertion hole and which controls the posture of the work chucking/inserting apparatus so that the work is inserted into the insertion hole in alignment with the hole.

According to the assembling unit in the above sixteenth aspect of the invention, a tracer control for the work chucking/inserting apparatus which control is made to detect the position of the insertion hole, the conveyance of the apparatus up to the position of the insertion hole, and a posture control for the apparatus with respect to the insertion hole, can be done automatically using the robot.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view showing the whole of an assembling unit equipped with an XYZ orthogonal coordinate robot on which is mounted a work chucking/inserting apparatus according to an embodiment (the first embodiment) of the invention described in the above first, sixth, ninth and sixteenth aspects;

Fig. 2 is a perspective view of the work chucking/inserting apparatus;

Fig. 3 is a perspective view of a posture control robot for controlling the posture of the work chucking/inserting apparatus around θ_x θ_y θ_z

axes which robot is interposed between the work chucking/inserting apparatus and the XYZ orthogonal coordinate robot;

Fig. 4 is an explanatory diagram showing, in a modeled form, the structure of a principal portion of the work chucking/inserting apparatus;

Fig. 5 is an explanatory diagram showing, in a modeled form, the structure of a principal portion of a work chucking/inserting apparatus according to an embodiment (the second embodiment) of the invention described in the above second aspect;

Fig. 6 is an explanatory diagram showing, in a modeled form, the structure of a principal portion of a work chucking/inserting apparatus according to an embodiment (the third embodiment) of the invention described in the above third and fourth aspects;

Fig. 7 is an explanatory diagram showing, in a modeled form, the structure of a principal portion of a work chucking/inserting apparatus according to an embodiment (the fourth embodiment) of the invention described in the above fifth aspect;

Fig. 8 is an explanatory diagram showing, in a modeled form, the structure of a principal portion of a work chucking/inserting apparatus according to an embodiment (the fifth embodiment) of the invention described in the above tenth aspect;

Fig. 9 is an explanatory diagram showing, in a modeled form, the structure of a principal portion of a work chucking/inserting apparatus according to an embodiment (the sixth embodiment) of the invention described in the above seventh aspect;

Fig. 10 is a diagram showing a modification of the sixth embodiment illustrated in Fig. 9;

Fig. 11 is an explanatory diagram showing, in a modeled form, the

structure of a principal portion of a work chucking/inserting apparatus according to an embodiment (the seventh embodiment) of the invention described in the above eighth aspect;

Fig. 12 is an explanatory diagram showing, in a modeled form, the structure of a principal portion of a work chucking/inserting apparatus according to an embodiment (the eighth embodiment) of the invention described in the above eleventh, twelfth and fourteenth aspects;

Fig. 13 is a diagram showing a series of operations of the work chucking/inserting apparatus illustrated in Fig. 12 in a successive manner;

Fig. 14 is an explanatory diagram showing, in a modeled form, the structure of a principal portion of a work chucking/inserting apparatus according to an embodiment (the ninth embodiment) of the invention described in the above thirteenth aspect;

Fig. 15 is a diagram showing a series of operations of the work chucking/inserting apparatus illustrated in Fig. 14 in a successive manner;

Fig. 16 is a diagram showing, in a successive manner, a series of operations of a work chucking/inserting apparatus according to an embodiment (the tenth embodiment) of the invention described in the above fifteenth aspect;

Fig. 17 is a diagram showing an operational step of inserting a work into an insertion hole with use of a conventional inserting jig;

Fig. 18 is a diagram showing another step using the conventional inserting jig; and

Fig. 19 is a diagram showing a further step using the conventional inserting jig.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The following description is now provided about an embodiment (the first embodiment) of the invention described in the above first, sixth, ninth and sixteenth aspects, which is illustrated in Figs. 1 to 4.

Fig. 1 is a perspective view showing the whole of an assembling unit equipped with an XYZ orthogonal coordinate robot on which is mounted a work chucking/inserting apparatus according to this first embodiment, Fig. 2 is a perspective view of the work chucking/inserting apparatus, Fig. 3 is a perspective view of a posture control robot for controlling the posture of the work chucking/inserting apparatus around θ_x θ_y θ_z axes which robot is interposed between the work chucking/inserting apparatus and the XYZ orthogonal coordinate robot, and Fig. 4 is an explanatory diagram showing the structure of a principal portion of the work chucking/inserting apparatus in a modeled form.

The work chucking/inserting apparatus of this first embodiment is used for inserting piston into a cylinder bore in alignment with the bore in an internal combustion engine assembling process. As shown in Fig. 1, in an assembling unit 1 for inserting a piston into a cylinder bore, a work support base 10 is installed centrally of a floor 2, a first XYZ orthogonal coordinate robot (hereinafter referred to as "the first robot") is installed on the right-hand side in Fig. 1 of the floor 2, and a second XYZ orthogonal coordinate robot ("the second robot" hereinafter) 30 is installed on the left-hand side in Fig. 1 of the floor 2. Between the work support base 10 and the first robot 20 is provided a temporary work rest 40.

The work support base 10 is provided on top thereof with a turntable 12 on which is placed a cylinder block 11 as one work. For inserting an assembly (see Fig.2, hereinafter referred to simply as

"assembly") 61 of a piston 62 and a connecting rod 63 into a cylinder bore 13 of the cylinder block 11, the first robot 20 carries the assembly 61 up to the position of the cylinder bore 13. The second robot 30 carries a pair of chuck arms 31 through an opposite-side opening of the cylinder bore 13 up to the interior of the bore, the chuck arms 31 functioning to chuck and guide a tip end portion of the connecting rod 63 to be inserted into the cylinder bore 13. On the temporary work rest 40 are rested a plurality of assemblies 61 as the other work, standing by for the work inserting operation into the cylinder bore 13. The cylinder block 11 is for four cylinders; that is, there are provided four cylinder bores 13 and four assemblies 61.

As shown in Fig. 2, each assembly 61 is chucked by the work chucking/inserting apparatus of this embodiment, indicated at 60. As shown in Fig. 3, the work chucking/inserting apparatus 60 is supported by a posture control robot 50. The posture control robot 50 is equipped with motors 51, 52 and 53 around three shafts θ_x θ_y θ_z for correcting an axial deflection and a rotational deflection of the assembly 61. As shown in Fig. 1, the posture control robot 50 is fixedly secured to a Y shaft of the first robot 20 and is thereby supported by the first robot 20.

Next, reference will be made below to the structure of the work chucking/inserting apparatus 60.

As shown in Fig. 2, the work chucking/inserting apparatus 60 has six piston chuck fingers 65 projecting in a leftward and downward direction in Fig. 2 from a base portion 64 of the apparatus. The six piston chuck fingers 65 are arranged circumferentially at equal intervals and can advance and retreat radially. Inner surfaces of the chuck fingers 65 serve as chuck surfaces for chucking the piston 62, while outer surfaces thereof are tapered at least at their tip end portions so that the closer to their tips,

the more inwards the taper. The shape formed by combination of all the six piston chuck fingers 65 is a tapered shape which is narrower at their tips, and the outer surfaces thus tapered of the piston chuck fingers can contact an inlet of the cylinder bore 13 being opened toward the first robot 20 side. In the illustrated embodiment, chuck fingers 65 are tapered over the greater part in the longitudinal direction thereof in such a manner that the closer to their tips, the more inwards the taper. The tapers of the outer surfaces of the piston chuck fingers 65 are arranged on a single (virtual) conical surface. The number of the piston chuck fingers 65 is three or more. If the piston chuck fingers 65 are arranged in circumferentially spaced positions, it will do. But preferably they are arranged at equal intervals in the circumferential direction.

The mechanism for causing the piston chuck finger 65 to advance and retreat radially on the base portion 64 is a known mechanism. Though not shown, a pin is projected on the back of a leg portion of each piston chuck finger 65, and a cam plate formed with a cam groove which the pin follows is accommodated in the interior of the base portion 64. As the cam plate rotates forward and reverse, the pin reciprocates in the cam groove in a relative manner and the piston chuck finger 65 integral with the pin advances and retreats radially. The rotation of the cam plate is performed by a motor 66.

An air chuck 67 is attached integrally to the base portion 64 and a pair of connecting rod chucking arms 68 extend from the air chuck 67 in the same direction as the piston chuck fingers 65. The connecting rod chucking arms 68 are L-shaped and the tips of their L shapes chuck a large-diameter side of the connecting rod 63 in alignment with the piston 62, the connecting rod 63 being mounted to the piston 62. By permitting or cutting

off the supply of air pressure to the air chuck 67, the paired connecting rod chucking arms 68 swing toward or away from each other. When the arms 68 swing toward each other, they chuck the large-diameter side of the connecting rod 63.

A force sensor 69 is integral with the back in Fig. 2 of the base portion 64. When the outer surfaces of the six piston chuck fingers 65 are brought into pressure contact with the inlet of the cylinder bore 13 (see Fig. 4) for detecting the position of the cylinder bore, the force sensor 69 detects the magnitude and direction of a resultant force F of reaction forces which the piston chuck fingers 65 receive from the cylinder bore 13. The resultant force F of the reaction forces comprises force components F_X, F_Y, F_Z and rotational force components $F_{\theta X}$, $F_{\theta Y}$, $F_{\theta Z}$ acting around the axis θ_x, θ_y and θ_z. Therefore, the resultant force F of reaction forces which the piston chuck fingers 65 receive from the cylinder bore 13 can be expressed as follows:

$$F = F(F_X, F_Y, F_Z, F_{\theta X}, F_{\theta Y}, F_{\theta Z})$$

That the force components F_X, F_Z, $F_{\theta X}$, $F_{\theta Y}$ and $F_{\theta Z}$ are present indicates that there occurs a relative positional deviation between the cylinder bore 13 and a virtual conical surface defined by the outer surfaces of the six piston chuck fingers 65 or a virtual cylindrical surface (chuck surface) defined by the inner surfaces of the six piston chuck fingers. In this connection, if the presence of the force components F_X, F_Z, $F_{\theta X}$, $F_{\theta Y}$ and $F_{\theta Z}$ is detected, the position of the work chucking/inserting apparatus having the six piston chuck fingers 65 is corrected repeatedly by a movement quantity control in XZ directions with use of the first robot 20 and also by a rotational quantity control around the θ_x, θ_y and θ_z axes with use of the posture control robot 50, which controls are made so that

those force components are eliminated, that is, there remains only the force component F_Y in Y direction.

In this way the position of the work chucking/inserting apparatus 60 is corrected repeatedly following the position of the cylinder bore 13. When the aforesaid force components have been eliminated or almost eliminated, the position of the work chucking/inserting apparatus 60 can be regarded as corresponding to an exact position of the cylinder bore 13. At this time, the axis of a single conical surface defined by the outer surfaces of the six piston chuck fingers 65 and the axis of a single cylindrical surface defined by the inner surfaces of the six piston chuck fingers are aligned with the axis of the cylinder bore 13, and the position of the work chucking/inserting apparatus 60 is memorized.

Since the six piston chuck fingers 65 of the work chucking/inserting apparatus 60, the first robot 20 and the posture control robot 50 function as above, it can be said that they combine together to constitute a tracer mechanism for detecting the position of the cylinder bore 13.

According to such a method for detecting the position of the cylinder bore 13, relative positional deviation quantity and rotational deviation quantity of the cylinder bore 13 with respect to the work chucking/inserting apparatus 60 are detected as electrical values and instructions are given to controllers of the first robot 20 and the posture control robot 50, causing the work chucking/inserting apparatus 60 to move in XZ plane or rotate around the XYZ rotary shafts so as to eliminate those deviations. Instead of such an electrical method there may be adopted a mechanical method.

As an example of a mechanical method there is known a method using a floating mechanism. According to this method, a floating

mechanism is used as a substitute for the force sensor 69 used in the above electrical method. In this case, the tip end portion of the work chucking/inserting apparatus 60, i.e., the tips of the six piston chuck fingers 65 of the work chucking/inserting apparatus 60, are brought into pressure contact with the inlet of the cylinder bore 13 and are then inched longitudinally (in Y direction). As a result, the floating mechanism operates and the work chucking/inserting apparatus 60 slides in XZ plane, permitting an automatic alignment.

As shown in Figs. 2 and 3, a mounting arm 70 projects from the back of the force sensor 69 attached to the work chucking/inserting apparatus 60 and is secured rotatably to a third frame 54 of the posture control robot 50, whereby the work chucking/inserting apparatus 60 is suspended from the posture control robot 50. A motor 51 is fixed to the third frame 54 and a rotary shaft thereof is connected to the mounting arm 70 so as not to permit a relative rotation thereof. Thus, with the motor 51, the work chucking/inserting apparatus 60 can rotate around the θ_x axis. The third frame 54 is suspended from a second frame 55 so that it can be rotated around the θ_y axis by means of a motor 52.

The second frame 55 is suspended from a first frame 56 so that it can be rotated around the θ_z axis by means of a motor 53. The first frame 56 is fixed to the Y shaft of the first robot 20. In this way the posture control robot 50 is supported by the first robot 20.

Since the work chucking/inserting apparatus 60 is thus suspended by the posture control robot 50 and the posture control robot 50 is thus supported by the first robot 20, it becomes possible to effect the position detection for the cylinder bore 13 which utilizes the tracer mechanism and an aligned insertion of an assembly 61 which will be described later into the

cylinder bore 13.

A more detailed description will be given below about the operations of the work chucking/inserting apparatus 60, the posture control robot 50 and the first and second robots 20, 30.

When the position of the cylinder bore 13 is detected in the manner described above, the axis of the cylinder bore 13 and that of a single conical surface defined by the arrangement of the outer surfaces of the six piston chuck fingers 65 or of a single cylindrical surface defined by the arrangement of the inner surfaces of the six piston chuck fingers are aligned with each other and the position of the work chucking/inserting apparatus 60 (the position on the XYZ shafts and a rotational position around the θ_x θ_y θ_z axes) in this instant is memorized. Therefore, the first robot 20 then leaves the detected position of the cylinder bore 13 and conveys the work chucking/inserting apparatus 60 up to the position of the temporary work (piston) rest 40.

At this time, the axis of a single conical surface defined by the arrangement of the outer surfaces of the six piston chuck fingers 65 is rendered vertical and the six piston chuck fingers 65 are moved so as to become positioned just above a specific piston 62 placed on the temporary work rest 40. The six piston chuck fingers 65 are then moved further downward by the first robot 20 and the motor 66 is turned ON to let the piston chuck fingers 65 advance and retreat radially, whereby the piston chuck fingers 65 can chuck the piston 62. The connecting rod 63 is integral with the piston 62 and is chucked by the paired connecting rod chucking arms 68 in alignment with the piston 62 when the piston chuck fingers 65 chucks the piston 62.

When the six piston chuck fingers 65 have thus chucked the piston

62, the first robot 20 conveys the work chucking/inserting apparatus up to the pre-memorized position on the XZ shafts, and the posture control robot 50 causes the work chucking/inserting apparatus 60 to rotate up to the pre-memorized rotational position around the θ_x θ_y θ_z axes, now ready for the start of operation for inserting the assembly 61 into the cylinder bore 13.

Then, the first robot 20 conveys the work chucking/inserting apparatus 60 along the Y shaft until the six piston chuck fingers 65 come into abutment against an end face of the inlet of the cylinder bore 13 and inserts the assembly 61 into the cylinder bore 13 from the tip end side of the connecting rod 63. Upon this insertion of the assembly 61 into the cylinder bore 13 the paired chuck arms 31 which have been moved into the cylinder bore 13 from the opposite-side opening of the bore and which are now in a stand-by state chuck the tip end portion of the connecting rod 63, then the paired connecting rod chucking arms 68 release the connecting rod 63 and retreat. At the same time, the paired chuck arms 31 also retreat. As a result, the piston 62 is drawn into the cylinder bore 13.

When the six piston chuck fingers 65 have come into abutment against the end face of the inlet of the cylinder bore 13, their inner surfaces are flush with the inner peripheral surface of the cylinder bore 13, and the axis of the cylindrical surface defined by the inner surfaces of the piston chuck fingers 65 is aligned with the axis of the cylinder bore 13, so that the piston 62 is inserted smoothly into the cylinder bore 13.

The above operations are repeated for each of plural cylinder bores 13.

Since this first embodiment is constructed as above, it is possible to obtain the following effects.

The work chucking/inserting apparatus 60 used for inserting the

piston 62 into the cylinder bore 13 in alignment with the bore has six piston chuck fingers 65, the piston chuck fingers 65 being arranged circumferentially at equal intervals and capable of advancing and retreating radially, the inner surfaces of the piston chuck fingers 65 serving as chuck surfaces for chucking the piston 62, the outer surfaces of the piston chuck fingers 65 being tapered at least at their tip end portions so that the closer to their tips, the more inwards the taper, and capable of coming into contact with the inlet of the cylinder bore 13.

As a result, the outer surfaces of the six piston chuck fingers 65 arranged circumferentially at equal intervals define a generally conical shape, which shape is suitable for searching for the position of the insertion hole (cylinder bore 13) for the piston 62. When the outer surfaces of the six piston chuck fingers 65 having such a shape are brought into contact equally with the inlet of the cylinder bore 13, it becomes possible to detect the position of the cylinder bore 13 accurately, and by merely fixing the work chucking/inserting apparatus 60 to the detected position and pushing (drawing) the piston 62 chucked by the inner surfaces of the six piston chuck fingers 65 toward the cylinder bore 13, it is made possible to insert the piston 62 into the cylinder bore 13 in alignment with the bore. Thus, with an extremely simple structure, the piston 62 can be inserted into and aligned with the cylinder bore 13 in a short time and in a high working efficiency.

Besides, the six piston chuck fingers 65 of the work chucking/inserting apparatus 60 can be advanced and retreated radially, so by adjusting the radial advance and retreat of the chuck fingers 65 in accordance with the size of the piston 62, it is possible to chuck, or handle, various sizes of pistons 62 and thus the work chucking/inserting apparatus

60 is suitable for an engine assembling line as a multi-type mixed production line.

Moreover, in the case where the work chucking/inserting apparatus 60 is provided with a tracer mechanism so that the axis of a conical surface defined by the outer surfaces of the six piston chuck fingers 65 is aligned with the axis of the cylinder bore 13 when the said outer surfaces contact the inlet of the cylinder bore 13, a mere operation of advancing the outer surfaces of the piston chuck fingers 65 toward the cylinder bore 13 permits detection of the cylinder bore 13 position, and thus the position of the cylinder bore 13 can be detected extremely easily.

Further, since the assembling unit 1 is equipped with a robot for conveying the work chucking/inserting apparatus 60 up to the position of the cylinder bore 13 and for controlling the posture of the work chucking/inserting apparatus 60 so that the piston 62 is inserted into the cylinder bore 13 in alignment with the bore, a tracer control for the work chucking/inserting apparatus 60 which is made for detecting the position of the cylinder bore 13, conveyance of the work chucking/inserting apparatus 60 up to the position of the cylinder bore 13 and a posture control for the work chucking/inserting apparatus 60 with respect to the cylinder bore 13 can all be done automatically by utilizing the robot.

Description will be directed below to an embodiment (the second embodiment) of the invention described in the foregoing second aspect, which is illustrated in Fig. 5.

Fig. 5 is an explanatory diagram showing, in a modeled form, the structure of a principal portion of a work chucking/inserting apparatus according to the second embodiment.

In the work chucking/inserting apparatus of the second

embodiment, indicated at 60, outer surfaces of six piston chuck fingers 65 are not tapered at their tip end portions 65a, but are arranged on a single (virtual) cylindrical surface, which is formed so as to become parallel to the inner peripheral surface of the cylinder bore 13 when the axis of the cylindrical surface and that of the cylinder bore 13 are aligned with each other. Therefore, when the six piston chuck fingers 65 are retreated radially, the tip end portions 65a of the outer surfaces of the six piston chuck fingers 65 can contact the inner peripheral surface of the inlet portion of the cylinder bore 13.

In the point just described above the second embodiment is different from the previous first embodiment, but there is nothing else different from the first embodiment, so a detailed description thereof will be omitted.

Since the second embodiment is constructed as above, if how the contact pressure varies among the six piston chuck fingers 65 upon contact of the tip end portions 65a of their outer surfaces with the inner peripheral surface of the inlet portion of the cylinder bore 13, is detected with use of the force sensor as the force sensor 69 used in the first embodiment, it is possible to detect the position of the cylinder bore 13. In addition, there can be attained the same effects as in the first embodiment. In this second embodiment, the mechanical method using a floating mechanism is most suitable for detecting the position of the cylinder bore 13.

Next, a description will be given below about an embodiment (the third embodiment) of the invention described in the foregoing third and fourth aspects, which is illustrated in Fig. 6.

Fig. 6 is an explanatory diagram showing, in a modeled form, the structure of a principal portion of a work chucking/inserting apparatus

according to the third embodiment.

In the work chucking/inserting apparatus of this third embodiment, indicated at 60, a position detecting function for the insertion hole (cylinder bore 13) and a work (piston 62) chucking and inserting function are imparted to two separate members respectively. In this point the third embodiment is different from the previous first embodiment. More specifically, inner surfaces of piston chuck fingers 65 serve as chuck surfaces for chucking the piston 62, but outer surfaces thereof are not concerned in detecting the position of the cylinder bore 13. It is hole position detecting fingers 71 separate from the piston chuck fingers 65 that are concerned in detecting the position of the cylinder bore 13.

The hole position detecting fingers 71 are provided in the same number, i.e., six, as the piston chuck fingers 65 and are arranged circumferentially at equal intervals. Base end portions of the hole position detecting fingers 71 are pivotally connected to tip end portions of the piston chuck fingers 65 so as to be pivotable inwards and outwards with their pivoted base ends as fulcrums. Like the outer surfaces of the piston chuck fingers 65 in the first embodiment, at least tip end portions 71a of the outer surfaces of the hole position detecting fingers 71 are tapered such that the closer to their tips, the more inwards the taper, and can contact the inner peripheral surface of the inlet portion of the cylinder bore 13.

The piston chuck fingers 65 and the hole position detecting fingers 71 both used in this third embodiment combine together to exhibit the same function as that of the piston chuck fingers 65 used in the first embodiment. The piston chuck fingers 65 used in the first embodiment correspond to a united one of both piston chuck fingers 65 and hole position detecting fingers 71 used in the third embodiment. After the hole position detecting

fingers 71 have played the role of detecting the position of the cylinder bore 13, they are pivotally moved outwards and are therefore not an obstacle to the insertion of the piston 62 into the cylinder bore 13.

This third embodiment is different in the above point from the first embodiment, but there is nothing else different from the first embodiment, so a detailed explanation thereof will be omitted.

Since the work chucking/inserting apparatus 60 of the third embodiment is constructed as above, the hole position detecting fingers 71 can fulfill the role of detecting the position of the cylinder bore 13 while the piston chuck fingers 65 continue to chuck the piston 62. Thus, it is not necessary for the work chucking/inserting apparatus to go to the temporary rest of the piston 62 and fetch the piston 62. Consequently, the piston 62 can be inserted into and aligned with the cylinder bore 13 in a still shorter time and in a still higher working efficiency than in the first embodiment.

Besides, since the base end portions of the hole position detecting fingers 71 are pivotally connected to the tip end portions of the piston chuck fingers 65, it is only a mechanical error between the hole position detecting fingers 71 and the piston chuck fingers 65 that comes into question at the time of inserting the piston 62 into the cylinder bore 13 in alignment with the bore which piston is chucked by the inner surfaces of the piston chuck fingers 65. Since this error is very small and can be corrected easily, the piston 62 can be inserted into and aligned with the cylinder bore 13 more accurately. In addition, there can be attained the same effects as in the first embodiment.

The following description is now provided about an embodiment (the fourth embodiment) of the invention described in the foregoing fifth aspect, which is illustrated in Fig. 7.

Fig. 7 is an explanatory diagram showing, in a modeled form, the structure of a principal portion of a work chucking/inserting apparatus according to the fourth embodiment.

In the work chucking/inserting apparatus of the fourth embodiment, indicated at 60, base end portions of six hole position detecting fingers 71 are pivotally connected to an outer periphery of a base portion 64.

In the above point this fourth embodiment is different from the previous third embodiment, but there is nothing else different from the third embodiment, so a detailed description thereof will be omitted.

Since the fourth embodiment is constructed as above, the hole position detecting fingers 71 can be pivotally supported more firmly and stably than in the third embodiment. In addition, there can be attained substantially the same effects as in the third embodiment.

A description will be given below about an embodiment (the fifth embodiment) of the invention described in the foregoing tenth aspect, which is illustrated in Fig. 8.

Fig. 8 is an explanatory diagram showing, in a modeled form, the structure of a principal portion of a work chucking/inserting apparatus according to the fifth embodiment.

In the work chucking/inserting apparatus of this fifth embodiment, indicated at 60, two of the six hole position detecting fingers 71 used in the fourth embodiment serve also as a pair of connecting rod chucking arms 68 (see Fig. 2) which are means for chucking the connecting rod 63.

To this end, the two hole position detecting fingers 71 are respectively formed with extending portions 71b which reach the connecting rod 63 at more inward positions than the tip end portions 71a of the outer surfaces which are tapered for detecting the position of the cylinder bore 13.

The remaining four hole position detecting fingers 71 do not have such extending portions 71b, but are of the same shape as the extending portions 71b-excluded shape of the above two hole position detecting fingers 71.

In the above point this fifth embodiment is different from the previous fourth embodiment, but there is nothing else different from the fourth embodiment, so a detailed explanation thereof will be omitted.

Since the fifth embodiment is constructed as above, the paired connecting rod chucking arms 68 can be constituted in an extremely simple manner without using any separate member different from the hole position detecting fingers 71. In addition, there can be obtained the same effects as in the fourth embodiment.

In the fifth embodiment it is not limited to the two hole position detecting fingers 71 that are used also as the paired connecting rod chucking arms 68. Four hole position detecting fingers may be divided into two on the right-hand side and two on the left-hand side and the resulting two pairs may be used for the same purpose. There also may be adopted a modification wherein one or two hole position detecting fingers 71 are attached to each of the paired connecting rod chucking arms 68.

Reference will now be made to an embodiment (the sixth embodiment) of the invention described in the foregoing seventh aspect, which is illustrated in Fig. 9.

Fig. 9 is an explanatory diagram showing, in a modeled form, the structure of a principal portion of a work chucking/inserting apparatus according to the sixth embodiment.

In the work chucking/inserting apparatus of this sixth embodiment, indicated at 60, there is provided a pushing mechanism 72 for pushing the piston 62 as the work toward the cylinder bore 13 as the insertion hole.

The pushing mechanism 72 is fixed to a base portion 64 on the side where piston chuck fingers 65 are provided, and it is provided with a cylinder 73 and a plunger 74 projecting from the cylinder 73. The plunger 74 is pushed with a pneumatic pressure or a hydraulic pressure and is thereby projected from the cylinder 73, whereby the piston 62 is pushed toward the cylinder bore 13 and is inserted into the cylinder bore 13. The pushing mechanism 72 may be constituted electrically.

The pushing mechanism 72 used in this sixth embodiment is applicable to any of the previous first to fifth embodiments. In this sixth embodiment, except the above point there is nothing else particularly different from those previous embodiments, so a detailed description thereof will be omitted.

Since the sixth embodiment is constituted as above, when the position of the cylinder bore 13 is detected and the sixth piston chuck fingers 65 chuck the piston 62 and upon alignment of the axis of a (virtual) cylindrical surface defined by the inner surfaces of the piston chuck fingers 65 with the axis of the cylinder bore 13, it becomes possible to push the piston 62 into the cylinder bore 13. Thus, the piston 62 can be inserted into and aligned with the cylinder bore 13 in a shorter time and in a higher working efficiency. Besides, since the Y shaft of the first robot 20 is not used for pushing the piston 62 into the cylinder bore 13, the piston 62 can be inserted into the cylinder bore 13 with a high accuracy while allowing the piston chuck fingers 65 to substantially stand still.

When the piston 62 is to be pushed into the cylinder bore 13, the piston chuck fingers 65 are slightly retreated radially, so that the chucking force of the sixth piston chuck fingers 65 for the piston 62 is weakened slightly, whereby the piston 62 is allowed to move toward the cylinder bore

13 while sliding on a cylindrical surface defined by the inner surfaces of the six piston chuck fingers 65. Thus, the piston 62 can be inserted into the cylinder bore 13 smoothly while preserving its posture without any damage thereto. In addition, there can be attained the same effects as in the previous first to fifth embodiments.

Fig. 10 illustrates a modification of the above sixth embodiment. In this modification, the piston 62 is provided with a piston ring 75 on its outer peripheral surface. The piston ring 75 is fitted in an annular groove formed in the outer peripheral surface of the piston 62 and possesses resilience. Therefore, a contact force most suitable for the piston ring 75 to slide on the inner chuck surfaces of the piston chuck fingers 65 can be obtained easily by adjusting the return quantity (retreat quantity) of the piston chuck fingers 65.

Description will now be directed to an embodiment (the seventh embodiment) of the foregoing eighth aspect, which is illustrated in Fig. 11.

Fig. 11 is an explanatory diagram showing, in a modeled form, the structure of a principal portion of a work chucking/inserting apparatus according to the seventh embodiment of the present invention.

In the work chucking/inserting apparatus of this seventh embodiment, indicated at 60, the inlet of the cylinder bore 13 is chamfered at 76, while tip end portions of six piston chuck fingers 65 are respectively formed with projections 77 which can fill up the chamfered portion 76. Therefore, when the tips of the six piston chuck fingers 65 are put in abutment against the inlet end faces of the cylinder bore 13 upon insertion of the piston 62 chucked by the six piston chuck fingers 65 into the cylinder bore 13, the projections 77 can fill up the chamfered portion 76 in that abutted position.

The chamfered structure of the inlet of the cylinder bore 13 and the projection structure of the tip end portions of the piston chuck fingers 65 capable of filling up the chamfered portion both adopted in this seventh embodiment, are applicable to all of the first to sixth embodiments. Particularly, in the case where the tip end portions of the outer surfaces of the piston chuck fingers 65 are tapered as in the first embodiment, this taper structure can be utilized in the above projection structure (see chain lines in Fig. 11). In this seventh embodiment there is nothing else different from those previous embodiments, so a detailed explanation thereof will be omitted.

Since the seventh embodiment is constructed as above, a continuous annular recess (groove) of a wedge-like section is not formed in the chamfered portion 76 when the piston 62 is inserted into the cylinder bore 13. Consequently, there is no fear of the front edge of the piston 62 being caught in the said annular recess and hence the piston 62 is inserted smoothly into the cylinder bore 13. Particularly in the case where the piston 62 is provided with the piston ring 75 as in the previous modification, there is no fear that the piston ring 75 which can behave independently of the piston 62 may drop into the annular recess. In this case, a particularly outstanding effect can thus be obtained.

The following description is now provided about an embodiment (the eighth embodiment) of the invention described in the foregoing eleventh, twelfth and fourteenth aspects, which is illustrated in Figs. 12 and 13.

Fig. 12 is an explanatory diagram showing, in a modeled form, the structure of a principal portion of a work chucking/inserting apparatus according to the eighth embodiment and Fig. 13 is a diagram showing a

series of operations of the work chucking/inserting apparatus in a successive manner.

In the work chucking/inserting structure of this eighth embodiment, indicated at 60, the structures of the work chucking/inserting apparatuses 60 described in the first, sixth and seventh embodiments are united, the inner surfaces of the chuck fingers are also tapered so that the closer to their tips, the more inwards the taper, and this taper structure is combined with the united structure.

In the work chucking/inserting apparatus 60 of this eighth embodiment, in comparison with the first embodiment, as shown in Figs. 12 and 13, there is further provided a pushing mechanism 72 for pushing the piston (work) 62 toward the cylinder bore (insertion hole) 3, and the inner surfaces of the chuck fingers 65 used respectively have tapered portions 78 which are tapered so that the closer to the tips, the more inwards the taper, and serve as chuck surfaces for chucking the piston 62. Further, the inlet of the cylinder bore 13 is chamfered at 76 and the tips (extremities of the tip end portions) of the outer surfaces of the chuck fingers 65 are formed so that they can be abutted against the chamfered portion 76 without leaving any gap when the piston 62 is inserted into the cylinder bore 13 (see Fig. 13g and 13h).

In the above points the eighth embodiment is different from the first embodiment, but there is nothing else different from the first embodiment, so a detailed explanation thereof will be omitted.

Next, the operation of the eighth embodiment will be described below with reference, as an example, to the case where the work chucking/inserting apparatus 60 is used in a vertically installed state.

In this eighth embodiment, when the work chucking/inserting

apparatus 60 detects the position of the cylinder bore 13, the inner surfaces of the chuck fingers 65 have already chucked the piston 62.

The work chucking/inserting apparatus 60 with the piston 62 thus already chucked by the chuck fingers 65 is first advanced (brought down), allowing the tapered tip end portions of the outer surfaces of the chuck fingers 65 to come into contact with one side of the chamfered portion 76 of the inlet of the cylinder bore 13, as shown in Fig. 13a. Next, the work chucking/inserting apparatus 60 is further advanced, allowing the tip end portions of the outer surfaces of the chuck fingers 65 to follow the chamfered portion 76. At the same time, the base portion 64, together with the chuck fingers 65, is moved gradually to the right in Fig. 13 by operation of the floating mechanism 69 as a tracer mechanism (Figs. 13b-d). When the work chucking/inserting apparatus 60 has come to be unable to further advance, the tip end portions of the outer surfaces of all the six chuck fingers 65 are in contact with the chamfered portion 76 without leaving any gap and the work for detecting the position of the cylinder bore 13 (horizontal positioning of the work chucking/inserting apparatus 60) is completed (Fig. 13d).

Next, the work chucking/inserting apparatus 60 is retreated (raised) to the position to which the tips of the chuck fingers 65 have advanced into the cylinder bore 13 by a distance corresponding to a vertical length (in the axial direction of the cylinder bore 13) of the chamfered portion 76, to complete a vertical positioning of the work chucking/inserting apparatus 60 (Fig. 13e). Then, the plunger of the pushing mechanism 72 is extended to push the piston 62, allowing the piston to slide on the tapered portions 78 of the inner surfaces of the chuck fingers 65. As a result, the tip end portions of the outer surfaces of the chuck fingers 65 are gradually

expanded radially outwards (Figs. 13f-h), permitting the piston 62 to pass through the expanded passage (piston insertion path). Thus, the piston 62 can be inserted into the cylinder bore 13 positively and smoothly while being guided by the tapered portions 78 without disengagement or drop from the chuck fingers 65. At this time, the tips of the outer surfaces of the chuck fingers 65 are in abutment with the chamfered portion 76 without leaving any gap.

Since this eighth embodiment is constructed and operates as above, the work chucking/inserting apparatus 60 need not go to the feed place of the piston 62 to fetch the piston 62, and the work for detecting the position of the cylinder bore 13 can be done while the piston 62 is kept chucked by the inner surfaces of the chuck fingers 65. Therefore, the piston 62 can be inserted into and aligned with the cylinder bore 13 in a still shorter time and in a still higher working efficiency. Thus, it is possible to make contribution to the improvement of productivity in an engine assembling line. Besides, even if there are not provided any special hole position detecting fingers (see the third embodiment) separately from the chuck fingers 65 for chucking the piston 62, it is not necessary for the work chucking/inserting apparatus to go to the piston feed place to fetch the piston 62. In other words, the structure of the work chucking/inserting apparatus 60 does not become complicated.

Further, since the mechanical floating mechanism 69 is used as the tracer mechanism, the work chucking/inserting apparatus 60 is simple in structure and low in cost, not using an complicated force control. In addition, there can be attained the same effects as in the first, sixth and seventh embodiments.

Next, a description will be given below about an embodiment (the

ninth embodiment) of the invention described in the foregoing thirteenth aspect, which is illustrated in Figs. 14 and 15.

Fig. 14 is a diagram showing, in a modeled form, the structure of a principal portion of a work chucking/inserting apparatus according to the ninth embodiment and Fig. 15 is a diagram showing a series of operations of the work chucking/inserting apparatus in a successive manner.

The work chucking/inserting apparatus of this ninth embodiment, indicated at 60, is different from that of the previous eighth embodiment in the shape of outer surfaces of chuck fingers 65 which function to not only detect the position of the insertion hole but also effect positioning of the work chucking/inserting apparatus 60. More specifically, in the eighth embodiment, like the first embodiment, the outer surfaces of the chuck fingers 65 are tapered at least at their tip end portions in such a manner that the closer to their tips, the more inwards the taper, and can contact the inlet of the cylinder bore 13, while in this ninth embodiment, end faces of the chuck fingers 65 are formed flat at their portions ("flat portions" hereinafter) exclusive of their inner edges and the vicinities thereof and can come into abutment against the wall surface which surrounds the inlet of the cylinder bore 13, and the inner peripheral edges and the vicinities thereof are tapered at 80 so that the closer to the tips, the more inwards the taper, and can contact the inlet of the cylinder bore 13. Further, the outer surfaces of the chuck fingers 65 are generally arcuate and perpendicularly contiguous to the end faces of the chuck fingers, not being particularly concerned in the detection of the insertion hole position or positioning of the work chucking/inserting apparatus 60.

In this ninth embodiment, the inner peripheral edges of the end faces of the chuck fingers 65 and the vicinities thereof are formed so that

they can be put in abutment against the chamfered portion 76 without leaving any gap upon insertion of the piston 62 into the cylinder bore 13 (see Figs. 15f and 15g) and so that the axis of a conical surface defined by the inner peripheral edges and the vicinities thereof of the end faces of all the six chuck fingers 65 is aligned with the axis of the cylinder bore 13 when those inner peripheral edges and the vicinities thereof come into contact with the inlet of the cylinder bore 13.

In the above points the ninth embodiment is different from the previous eighth embodiment, but there is nothing else different from the eighth embodiment, so a detailed explanation thereof will be omitted.

The operation of the ninth embodiment will be described below with reference, as an example, to the case where the work chucking/inserting apparatus 60 is used in a vertically installed state.

The function of the ninth embodiment is different from that of the eighth embodiment in the sequence and concrete mode of both operations one of which is detecting the position of the insertion hole by the work chucking/inserting apparatus 60 (horizontal positioning of the work chucking/inserting apparatus 60) and the other of which is positioning the work chucking/inserting apparatus 60 at the time of insertion of the work into the insertion hole (vertical positioning of the work chucking/inserting apparatus 60).

In connection with the sequence of both operations, in the previous eighth embodiment there is first performed the operation of detecting the position of the cylinder bore 13 by the work chucking/inserting apparatus 60 (horizontal positioning of the work chucking/inserting apparatus 60) and there is next performed the operation of positioning the work chucking/inserting apparatus 60 at the time of insertion of the piston 62

into the cylinder bore 13 (vertical positioning of the work chucking/inserting apparatus 60), whereas this sequence is reversed in this ninth embodiment.

In the ninth embodiment, as shown in Fig. 15a, the work chucking/inserting apparatus 60 with the piston 62 already chucked by the chuck fingers 65 is first advanced (brought down), allowing flat portions 79 of end faces of the chuck fingers 65 to come into abutment against the wall surface which surrounds the inlet of the cylinder bore 13, whereby the vertical positioning of the work chucking/inserting apparatus 60 is completed (Fig. 15b). Next, the plunger of the pushing mechanism 72 is extended to push the piston 62, allowing the piston 62 to slide on the tapered portions 78 of the inner surfaces of the chuck fingers 65, whereby the tips of the chuck fingers 65 (the tapered portions 80 of the inner peripheral edges of the end faces and the vicinities thereof) are gradually expanded radially outwards in equal quantities for all of the six chuck fingers 65, allowing the tips of the chuck fingers 65 to follow the chamfered portion 76. At the same time, the base portion 64, together with the chuck fingers 65, is gradually moved rightwards in Fig. 15 by operation of the floating mechanism 69 as the tracer mechanism (Figs. 15c-e).

In this way it becomes possible for the piston 62 to pass through an expanded passage (piston insertion path) which results from the tips of the chuck fingers 65 being expanded radially outwards, and the tapered portions 80 of the inner peripheral edges and the vicinities thereof of the end faces of all the six chuck fingers 65 come into contact with the chamfered portion 76 to complete the operation for detecting the position of the cylinder bore 13 (horizontal positioning of the work chucking/inserting apparatus 60) (Fig. 15e).

Next, the plunger of the pushing mechanism 72 is further extended

to push the piston 62, whereby the piston 62 can be inserted into the cylinder bore 13 without disengagement or drop from the chuck fingers 65. At this time, the tapered portions 80 of the end face inner peripheral edges and the vicinities thereof of the chuck fingers 65 are in abutment against the chamfered portion 76 without leaving any gap.

Since this ninth embodiment is constructed and operates as above, when the work chucking/inserting apparatus 60 detects the position of the cylinder bore 13, the flat end face portions 79 of the chuck fingers 65 can be allowed to serve as surfaces for positioning the work chucking/inserting apparatus 60 in the axial direction of the cylinder bore 13, and the apparatus 60 can be brought into a standstill in that direction, with elimination of an axial deflection. These points combine to improve the accuracy of detecting the position of the cylinder bore 13. Besides, the detection of the positions of the cylinder bore 13 and the insertion of the piston 62 into the cylinder bore 13 can be done simultaneously. Consequently, the piston 62 can be inserted into and aligned with the cylinder bore 13 in a still shorter time and in a still higher working efficiency. In addition, there can be attained the same effects as in the first, sixth, seventh and eighth embodiments.

Next, reference will be made below to an embodiment (the tenth embodiment) of the invention described in the foregoing fifteenth aspect, which is illustrated in Fig. 16.

Fig. 16 is a diagram showing, in a successive manner, a series of operations of a work chucking/inserting apparatus according to this tenth embodiment.

The work chucking/inserting apparatus of this tenth embodiment, indicated at 60, is different from the previous eighth and ninth

embodiments in that it uses a pushing mechanism 72 possessing a sucking function for the work (piston 62). To be more specific, a plunger which constitutes the pushing mechanism 72 is formed with a through hole communicating with a vacuum source, though not shown in detail.

Since the tenth embodiment is constructed as above, the operation thereof is different as follows from the previous eighth and ninth embodiments.

A description will now be given with the eighth embodiment as a comparative example. In the operations of the eighth embodiment illustrated in Figs. 13f, et seq., the plunger of the pushing mechanism 72 is extended to push the piston 62, the piston 62 is allowed to slide on the tapered portions 78 of the inner surfaces of the chuck fingers 65, thereby gradually expanding the tips of the chuck fingers 65 radially outwards to permit the piston 62 to pass through the thus-expanded passage (piston insertion path) into the cylinder bore 13 without disengagement or drop from the chuck fingers 65. On the other hand, in this tenth embodiment, the radially outward expansion of the tips of the chuck fingers 65 is performed by operation of a base portion 64 which holds the chuck fingers 65 in a radially advancible and retreatable manner.

When the tip ends of the chuck fingers 65 are expanded radially outwards by operation of the base portion 64, the piston 62 is released from the chuck fingers 65, but is not disengaged, nor drops, from the work chucking/inserting apparatus 60 because the piston 62 is sucked by the plunger of the pushing mechanism 72 (Fig. 16f). When a continued operation of the base portion 64 has expanded the tips of the chuck fingers 65 radially outwards until abutment against the chamfered portion 76, the plunger of the pushing mechanism 72 is extended to push the piston 62

gradually, whereby the piston 62 can be inserted into the cylinder bore 13 (Figs. 16f-h). In this case, the degree of expansion of the tips of the chuck fingers 65 caused by operation of the base portion 64 is preferably adjusted so that the piston 62 is allowed to slide only the last slight distance on the tapered portions 78 of the inner surfaces of the chuck fingers 65, whereby the tapered portions 78 can be allowed to serve as a guide for insertion of the piston 62 into the cylinder bore 13.

A description will now be given with the ninth embodiment as a comparative example. In the operations of the ninth embodiment illustrated in Figs. 15c et seq., the plunger of the pushing mechanism 72 is extended to push the piston 62, allowing the piston 62 to slide on the tapered portions 78 of the inner surfaces of the chuck fingers 65, thereby gradually expanding the tips of the chuck fingers 65 (the tapered portions 80 of the inner peripheral edges of end faces and the vicinities thereof) radially outwards so as to permit the piston 62 to pass through the thus-expanded passage (piston insertion path), and the position of the cylinder bore 13 is detected, whereby the piston 62 can be inserted into the cylinder bore 13 without disengagement or drop from the chuck fingers 65. On the other hand, in this tenth embodiment, the radially outward expansion of the tips of the chuck fingers 65 is effected by operation of a base portion 64 which holds the chuck fingers 65 in a radially advancible and retreatable manner.

The operation of the base portion 64 and that of the pushing mechanism 72, as well as the mode of insertion of the piston 62 into the cylinder bore 13 based on those operations, should be fully understood from the above descriptions, so a detailed description thereof will here be omitted.

Since the tenth embodiment is constructed and operates as above,

even if the inner surfaces of the chuck fingers 65 have already chucked the piston 62 before the work chucking/inserting apparatus 60 detects the position of the cylinder bore 13, there is no fear of the piston 62 being disengaged or dropping from the work chucking/inserting apparatus 60 when the tips of the chuck fingers 65 are expanded radially outwards for passage of the piston 62 or for detecting the position of the cylinder bore 13, because the piston 62 is sucked by the plunger of the pushing mechanism 72, thus permitting the piston 62 to be inserted positively into the cylinder bore 13. Besides, there is no fear of damage to the piston 62 because the piston 62 is little pushed by the pushing mechanism 72 for sliding on the tapered inner surface portions 78 of the chuck fingers 65.

Although in all of the above first to tenth embodiments the number of the piston chuck fingers 65 is six, there is made no limitation thereto insofar as there are three or more such fingers. Particularly, the minimum number will do if the hole position detecting fingers 71 are provided separately. Even two will do if a wide chuck surface can be ensured.

Further, although in the above first to seventh embodiments the piston 62 is inserted horizontally into the cylinder bore 13, this constitutes no limitation. The piston may be inserted into the cylinder bore vertically from above. Various other changes and modifications may be made within the scope not departing from the gist of the present invention.